REPORT ON WATER SUPPLY

FORT HUACHUCA AND VICINITY, ARIZONA

MAIN REPORT

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
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REPORT ON WATER SUPPLY
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SUMMARY OF FINDINGS

Adequate ground water is available in the upper San Pedro River basin to support present and forseeable future growth at Fort Huachuca and in surrounding areas. Production wells can be located in the East Range of Fort Huachuca. The capital costs of modifying the existing water supply system to meet present deficiencies of the system, plus inclusion of provisions for future expansion, were estimated at $920,000 (1974 prices). The total capital cost of modifying the existing water supply system to meet present deficiencies and of expanding the Post's water supply system to meet assumed daytime Post populations of 25,000 and 50,000, are estimated at $2,330,000 and $6,180,000, respectively, under 1974 prices. An alternative supply of water would result from construction of Charleston Reservoir, as authorized under the Central Arizona Project. However, the Bureau of Reclamation has assigned a relatively low priority to this work; construction is not expected prior to 1985.

The District Engineer recommends that this report be used as a basis for future planning for Fort Huachuca.

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AUTHORITY

The survey of water resources for Fort Huachuca and surrounding areas in the upper San Pedro River basin, Arizona, was authorized by TWX dated 20 June 1972, Subject: "Water Resources, Fort Huachuca" from the Department of the Army to STRATCOM, which stated that future master planning of activities at Fort Huachuca is dependent on water consumption and growth rate of both the installation and the surrounding community. It further stated that it is essential to obtain additional data on the water situation and that technical assistance will be provided by the District Engineer, Los Angeles. South Pacific Division letter dated 15 November 1972, Subject: "Water Supply Study, Fort Huachuca, Arizona," assigns to the Los Angeles District "primary responsibility for providing assistance to STRATCOM in support of its efforts to determine the impact of available water resources in the Fort Huachuca area on its long-range developments. This assistance is to include all necessary interagency coordination and preparation of appropriate studies and reports needed by STRATCOM. The Sacramento District is assigned technical responsibility in support of the Los Angeles District in all engineering-geological aspects of the effort."

SCOPE

This report presents the following:

a. An evaluation of the water supply needs for Fort Huachuca and vicinity under various population projections.

b. An overall assessment of the ground-water resources in the San Pedro River basin in the reach between the International Boundary on the south (upstream limit) and the Babocomari River on the north (downstream limit).

c. Results of a test well drilling program in the East Range of Fort Huachuca.

d. Results of a digital model analysis by the Arizona Water Commission showing the effect of increased pumpage in the region on the ground-water resources in the Fort Huachuca area, under various population projections.

e. Concept designs and cost estimates for expanding the Post's water supply system.

HISTORY OF POST

a. Fort Huachuca was established in 1881 for the support of Army troops in the Apache Indian Wars, and played a prominent part in the

Villa Punitive Expedition into Mexico in 1916. Various troops of cavalry and infantry regiments occupied the Post from 1888 to 1942.

b. In 1942 the installation was expanded to serve as an Army training center during World War II.

c. In the post World War II period, from 1947 to 1951, the installation was closed, and a small crew of civilian employees was housed on the Post for fire protection and custodial maintenance.

d. From 1951 to 1953 the U. S. Air Force reoccupied the Post and utilized it for training engineer aviation troops.

e. From 1953 to 1954 the Post was again placed in an inactive status with custodial maintenance.

f. In 1954 the Post was again activated and was known as the U. S. Army Electronic Proving Ground. In 1967, Fort Huachuca became the headquarters of the U. S. Army Communication Command, under which it is functioning as of this date.

GENERAL DESCRIPTION OF AREA

Fort Huachuca is located in Cochise County in the southeast portion of Arizona, about 75 miles southeast of Tucson. The base is within the San Pedro River drainage basin, which is a narrow southeast-northwest trending area running from the headwaters in the Mexican State of Sonora to its confluence with the Gila River at Winkelman, Arizona. The total drainage area comprises 4,483 square miles, of which 696 square miles are in Mexico. The Fort Huachuca Military Reservation is irregularly shaped and comprises 115 square miles (73,379 acres), of which one-third lies in the rugged terrain of the Huachuca mountains and its foothills in the southwesterly portion of the reservation. The remainder of the area slopes northerly to the Babocomari River and northeasterly to the San Pedro River. Elevations within the reservation vary from 3,900 to 8,700 feet above sea level. The reservation is climatically dominated by mild winters and relatively warm summers. Average annual rainfall is about 16 inches at Post Headquarters and as much as 26 inches in the mountain range.

The portion of the San Pedro River basin that is of primary concern is the area between the Mexican border on the upstream, or south end, and the Babocomari River at the downstream, or north end (see plate 1). The drainage area of the San Pedro River at a point downstream from the Babocomari River is 1,910 square miles.

HYDROLOGIC SYSTEM

The ultimate source of all ground water and surface water is from precipitation on the land surface. This precipitation infiltrates into

the soil, unless the infiltration capacity of the soil is exceeded. If the infiltration capacity of the soil is exceeded, the excess precipitation becomes runoff and flows overland to stream channels. Significant amounts of water infiltrate to the ground-water reservoir in certain parts of the San Pedro basin. The processes by which infiltration occur are: (1) direct infiltration from rainfall into underlying materials; (2) infiltration from runoff that originates in the mountains and seeps into the alluvial materials adjacent to the mountain front; and (3) infiltration from streamflow along the channel course.

The magnitude of direct infiltration from rainfall is not considered to be significant. The major sources of replenishment to the ground-water reservoir are mountain front recharge and channel infiltration.

The ground-water basin is mostly recharged along the mountain fronts and along the upper reaches of washes where water flows from the mountain canyons onto the valley slopes. Streamflow in washes originating near the mountain front seldom reaches the San Pedro River, except during torrential summer storms or exceptionally prolonged cyclonic winter precipitation. A portion of the streamflow infiltrates into the permeable material underlying the stream channels and percolates to the ground-water reservoir, but much of the surface flow emerging from the mountain canyons is lost by evapotranspiration. The ground-water reservoir occurs in the subsurface and the water level gradient generally parallels the topographic gradient, except near pumping centers. Groundwater emerges as base flow in the San Pedro River and to a minor extent in the Babocomari River, where it is again subject to evapotranspiration loss.

Along the San Pedro River, ground water is forced to the surface by a ground-water barrier formed by consolidated volcanic and sedimentary rocks which crop out near Charleston. Ground-water discharge to the river channel thus maintains a short reach of perennial flow at this location.

An additional source of ground-water input, to the area of interest, is ground-water underflow northward along the axis of the San Pedro River valley. The total underflow has been estimated to be 3,400 acre-feet per year at the international border and 2,800 acre-feet per year at Palominas, located about 4.5 miles north of the International Boundary. The difference of 600 acre-feet is lost through evapotranspiration by crops and phreatophytes.

GROUND WATER

A 1973 water level contour map of the Fort Huachuca area was prepared based on data from the Corps of Engineers, the Arizona Water Commission, and the U. S. Geological Survey (see Plate 3). The data indicate the presence of a perched mountain front ground-water body and a regional ground-water body.

Perched Mountain Front Groundwater. The perched ground-water body extends northwestward from the vicinity of Carr Canyon toward the Fort

Huachuca Military Reservation boundary, and extends northeastward toward the San Pedro River. This occurrence is indicated by unusually high water levels in wells in the area where the steep ground-water gradient is approximately 300 feet per mile. In contrast, the average gradient in the regional ground-water aquifer is about 25 feet per mile.

This perched ground-water body probably receives recharge from streams and springs which drain the adjacent portion of the Huachuca Mountains. Downward leakage from this perched zone recharges the regional ground-water body in limited amounts.

Regional Ground Water Body. The regional ground water body is made up of two parts - a regional aquifer and a flood plain aquifer. The regional aquifer comprises the saturated portions of alluvial deposits, except that portion along the principal streams. The water level contour map indicates that water enters this aquifer as mountain front recharge from the Huachuca Mountains and moves in a northeasterly direction toward the Babocomari and San Pedro Rivers. The water level contours comprise prominent lobes pointing in an upstream direction in both of these drainages, indicating that ground water discharges into the drainage channels. These two rivers act as drains for effluent flow from the ground-water system.

Two significant cones of depression have developed in the area due to pumping in the Fort Huachuca-Sierra Vista area and the Huachuca City area, which includes the former community of Huachuca Vista. The depression cone in the Fort Huachuca-Sierra Vista area is centered about the military post well field and appears to extend for approximately 4 miles, elongating in a northwest-southeast direction along the mountain front. The cone of depression is approximately 1.5 miles wide.

The depression cone in the Huachuca City area extends approximately 3 miles along Babocomari River, elongating in a southwest-northeast direction along the river channel. Heavy pumping in the Huachuca Vista area has apparently reversed the direction of ground-water flow along the reach of the Babocomari River for several miles downstream from Huachuca City. Ground water that formerly followed the Babocomari River to the northeast has been diverted to the southwest and enters the depression cone around Huachuca City.

The water level contours indicate that the flood plain alluvium receives recharge from ground-water underflow in the regional aquifer system, as well as from streamflow. In some reaches, ground water is discharged from the stream alluvium and comprises base flow to the Babocomari and San Pedro Rivers.

ECONOMIC DEVELOPMENT

The economy of the area surrounding the base has been predominantly agricultural. In recent years, the economy has been directly tied to the activities and population of Fort Huachuca. Since World War II,

satellite communities, such as Sierra Vista and Huachuca City, catering to the needs for services, recreation, housing, and a source of civilian labor have risen outside the base boundaries. The present population on the base and in the surrounding communities is estimated at 12,000 and 10,000, respectively. A new subdivision is proposed at the eastern boundary of Fort Huachuca by Tenneco, Inc., which owns much of the land along San Pedro River. The subdivision, to be called Pueblo del Sol, has been submitted to the State of Arizona for a determination on the adequacy of the water supply. The development is proposed to support a population of about 40,000.

PRESENT WATER SUPPLY

Presently, water for the Post is obtained from six deep wells clustered in an area about 1/4 mile wide and 1-1/2 miles long, between the Post's main gate and east gate (see Plate 2), and from collection systems in the Huachuca Canyon and the Garden Canyon spring areas.

The water supply in the area off the Post is principally from wells. The satellite community of Sierra Vista, just outside the Post's main gate, has experienced an expansion in recent years that saw its population increase from 3,100 in 1960 to nearly 7,800 in 1970; future growth will be geared to the needs of the Post. Huachuca City to the north of the Post is of more recent origin and, due to its geographical location, will probably not experience the rate of growth enjoyed by Sierra Vista. Water for all of these communities is obtained from wells tapping the same aquifer as the Post wells. The major water production wells for the Post and Sierra Vista, about 15 in number, are all clustered in an area near the main gate of the Post and can be contained in a circle of about 3 miles in diameter. The high concentration of wells in this locality has resulted in a substantial lowering of the water table under the wells. A similar situation has developed in the Huachuca City area.

The total present water consumption at Fort Huachuca, exclusive of sewage effluent irrigation, is about 3,000 acre-feet per year. The present six wells are capable of producing 3,500,000 gallons per day (16-hour operation) or 4,000 acre-feet per year. The canyon springs produce additional water; however, because of limited data, no average annual yield was determined. Records indicate that for one period (July 1971-July 1972) water production from the springs amounted to about 40 million gallons or 120 acre-feet. An additional 1,500,000 gallons per day, or about 1,600 acre-feet per year, of treated sewage effluent is available for irrigation.

The total present water consumption for the surrounding communities of Huachuca City and Sierra Vista is estimated at about 500,000,000 gallons per year, or about 1,500 acre-feet per year. All of this water is obtained from wells. The total water consumption for the Post and the two communities is therefore about 4,500 acre-feet under present conditions.

Water levels fluctuate seasonally in response to pumping and recharge in the San Pedro River valley, but in the last 25 years the net change has been small except in the Sierra Vista-Fort Huachuca, and Huachuca City areas. In these areas, cones of depression have developed and the water levels at the various Post wells have been dropping at a rate ranging from one to two feet per year, with a maximum decline of nearly 60 feet in 29 years in one of the wells. As withdrawal continues in excess of recharge, the cones of depression will expand and deepen. From 1965 to 1969, the water level in a well about 6 miles east of Sierra Vista declined 9 feet, owing to the expansion of the cone of depression. The depth to the water level at the six wells in Fort Huachuca averages about 500 feet.

WATER PROBLEMS

Fort Huachuca is withdrawing water from a ground-water basin that also serves the surrounding communities. This pumping has lowered the ground-water table 60 feet in 29 years in one of the Post wells. As withdrawals continue in excess of recharge, existing cones of depression will expand and deepen. Major developments are being proposed in the Sierra Vista area that might have a substantial impact on the ground-water situation. It is necessary to evaluate the water supply available to the base to determine its adequacy based on present and projected conditions.

In addition, although the existing six wells are capable of producing water to meet the present demand on an average annual basis, the six wells do not meet the criteria as set forth in Army TM 5-813 series manuals. The manuals require that the daily demand be met by operating the pumps for not more than 16 hours per day and that the well field should be capable of delivering the total daily demand while the highest capacity well pump is temporarily out of service. At present, the entire six wells cannot deliver the daily design demand of 4.613 million gallons per day in the maximum-use month of May, even if pumping were continuous for the entire 24 hours.

The Huachuca and Garden Canyons springs contribute an appreciable amount of good quality water to the Post water supply system. Since 1969, when these facilities were developed, the greatest daily production was recorded as 1,190,000 gallons and the minimum was 9,000 gallons. Inasmuch as these springs are not a reliable source of water during the dry season when maximum use occurs, they do not contribute appreciably to meeting the daily requirement. However, these springs provide a valuable resting period for the wells during the rainy season and during snow-melt conditions.

Two wastewater plants at the Post provide treated sewage effluent to irrigate the 18-hole golf course and Chaffee Parade Grounds. About 1,500,000 gallons per day, or over 1,600 acre-feet per year, of this water is available. If approval can be obtained from the medical department to use wastewater to irrigate some of the other areas now being irrigated with potable water, some relief in well production could be provided.

FUTURE WATER REQUIREMENTS

POPULATION

Four alternative population levels were considered for Fort Huachuca and the surrounding area for the period 1974-2060. They are used in the report to assess the effects of different levels of demand on the groundwater system. These projected levels for Fort Huachuca do not reflect anticipated strength at the Post. Populations were projected from 1974-2030 and were then assumed constant to the end of the study period, 2060. These alternatives reflect different assumptions of population levels at Fort Huachuca. Alternative I assumes a daytime population at the Post of 25,000 and a nighttime population of 20,500. Alternative II assumes that the present Fort complement of 12,000 would remain. Alternatives III and IV assume nighttime population levels of 40,000 and 50,000, respectively, at the Fort by the year 2000.

The population estimate for the study area reflects the personnel at Fort Huachuca, the communities of Sierra Vista and Huachuca City, and the surrounding area in the upper San Pedro River basin. Alternative population levels examined in this report are as follows:

Alternative Population Levels

	Year			
	1974	1980	2000	2030
Alternative I				
Study area	22,000	33,500	42,500	55,000
Fort Huachuca	12,000	20,500*	20,500*	20,500*
Alternative II				
Study area	22,000	25,000	34,000	46,500
Fort Huachuca	12,000	12,000	12,000	12,000
Alternative III				
Study area	22,000	38,000	72,000	84,000
Fort Huachuca	12,000	25,000	40,000	40,000
Alternative IV				
Study area	22,000	38,000	94,000	106,500
Fort Huachuca	12,000	25,000	50,000	50,000

* Nighttime population. Daytime population is estimated at 25,000.

FUTURE WATER DEMANDS

Projected annual water demands for Fort Huachuca and the remainder of the study area were developed by applying average daily per capita water use to the projected population levels. Projected water demands

for Fort Huachuca were computed on the basis of an average daily per capita consumption of 200 gallons and the assumption that golf course and parade ground irrigation would be accomplished using sewage effluent. All other projected water demands in the study area are based upon an average daily per capita consumption of 160 gallons. The daily consumption levels at Fort Huachuca reflect the historically higher water consumption levels experienced at the Fort relative to the surrounding areas. A summary of estimated annual water demand in acre-feet for each alternative level of population in the study area is as follows:

Estimated Annual Water Demands

	1974	1980	2000	2030
Alternative I				
Study area	4,500	7,000	8,600	10,800
Fort Huachuca	3,000*	4,600	4,600	4,600
Alternative II				
Study area	4,500	5,100	6,600	8,900
Fort Huachuca	3,000*	2,700	2,700	2,700
Alternative III				
Study area	4,500	8,000	14,700	16,900
Fort Huachuca	3,000*	5,600	9,000	9,000
Alternative IV				
Study area	4,500	8,000	19,100	21,300
Fort Huachuca	3,000*	5,600	11,200	11,200

* Present water use averages about 220 gallons per capita per day. Future demands were reduced to 200 gallons per capita per day to reflect the experiences of the Arizona Water Commission, which indicates that 200 gallons per capita per day should be sufficient to meet the Post's needs.

WATER QUALITY

Water quality analyses were made at the test wells on the East Range, as discussed under a subsequent heading. These analyses indicated that the quality of ground water in the East Range is suitable for domestic use and public supply.

POTENTIAL WATER SUPPLY - AVAILABILITY OF GROUND WATER

The U. S. Geological Survey has made preliminary studies to determine the amount of water in the underground basin along the San Pedro River between the International Boundary and the Babocomari River. Data from existing wells indicate the following:

(1) That the existing water table is conservatively estimated to average at about 175 feet below ground surface. (The water level at 110 wells averaged about 159 feet below the ground surface.)

(2) That ground water extends to a depth of at least 1,200 feet in the area bordering the river.

The thickness of alluvium in the San Pedro River valley is estimated to vary from about 300 feet near the foot of the mountains to over 1,200 feet at the valley floor. Lines showing equal depths of alluvium of 300 feet, 700 feet, and 1,200 feet below the existing ground surface were drawn by the U. S. Geological Survey on map (Plate 3). The areal extent of such thickness of alluvium is as follows:

Depth of Alluvium (feet)	Areal Extent: Entire Drainage Basin (Sq. mi.)	Areal Extent: West of San Pedro River (Sq. mi.)
300	405	270
700	318	222
1,200	175	133

On the basis of the thickness of alluvium and on the measured water levels in 110 wells, and applying appropriate specific yields for the underground basin, determined from drill-cuttings, geophysical logs, and aquifer pump tests, the U. S. Geological Survey estimates that there are presently about 19,500,000 acre-feet of water in storage in this reach, of which about 13,400,000 acre-feet of water are stored on the west side of the river.

Under Alternative Water Demand I, which assumes a nighttime Post population of 20,500 and a study area population of 55,000 in year 2030, about 810,000 acre-feet of water would be required in the study area during the period 1974-2060. The total water in ground-water storage on the west side of the valley is conservatively estimated at 13,400,000 acre-feet. Assuming no recharge to the ground-water basin, assuming water use after year 2060 at the same rate as for year 2060, and assuming that producing wells can be located in the area, it would take over 1,200 years to deplete the ground-water basin on the west side. Or stated another way, the total volume of water in storage in the study area is conservatively estimated to be over 15 times the projected demand to year 2060. In addition, about 6,000,000 acre-feet of water is available on the east side.

Under Alternative Water Demand IV, which assumes an optimistic Fort population of 50,000 and a study area population of 106,500 in year 2030, about 1,560,000 acre-feet of water would be required in the study area during the period 1974-2060. Again, making the same assumptions as for Alternative I, it would take about 640 years to deplete the ground-water basin on the west side. Or stated another way, the total volume of storage in the study area is conservatively estimated to be over eight times the projected demand to year 2060.

Only a portion of the total projected demand will be withdrawn from ground-water storage. Significant amounts of ground water are presently lost from the area via evapotranspiration by phreatophytes, ground-water discharge to surface flow which leaves the area via San Pedro River and subsurface underflow. Lowering of the ground-water table would result in the interception of some of these flows, which would prolong the life of the ground-water basin.

In addition, if the ground-water table were lowered along the San Pedro and Babocomari Rivers (which might occur subsequent to year 2060), part of the surface flows during storms would infiltrate the stream channel and recharge the ground-water basin.

The total amount of flow that might be salvaged at such times as the ground-water table were lowered along the San Pedro and Babocomari Rivers is roughly estimated at 14,300 acre-feet. This amount is greater than the total demand in the study area at year 2030 under Alternative I and is roughly two-thirds the total demand in the study area at year 2030 under Alternative IV. This recharge would extend the life of the ground-water basin indefinitely under Alternative I and would substantially prolong the life of the ground-water basin under Alternative IV.

TEST WELL DRILLING PROGRAM

Four distinct areas of Fort Huachuca were considered as potential locations for new wells: (a) North of the Post proper and west of Highway 90, (b) the Post Well Field-Sierra Vista area, (c) the strip of alluvial apron extending southeast of the Post Well Field to the mouth of Garden Canyon, and (d) the East Range area. As discussed in Appendix 4, the East Range offers the best prospects for future well production. The East Range is an extensive area of 44 square miles, mostly isolated from private developments that might compete with the Post for water. The areal extent permits sufficient spread between production wells to minimize interference of wells with each other. A test well drilling program on the East Range was therefore conducted by the Sacramento District to obtain conclusive evidence as to whether hydrogeologic conditions are such that production wells could be expanded into that area in the future, as required. The drilling program resulted in an affirmative determination; it disclosed that production wells adequate to meet the demands of the Fort can be located in the East Range. The program also provided factual data which were used by the Arizona Water Commission in developing the underground basin parameters used as input to the digital model analysis. In addition, the Sacramento District, on the basis of data obtained from the drilling program, identified on a preliminary basis the locations of proposed production wells (see Plate 2) so that concept designs and cost estimates for expanding the water supply system could be developed. More detailed information regarding the test well drilling study is contained in Appendix 4.

STUDIES OF THE ARIZONA WATER COMMISSION

A digital model analysis was made by the Arizona Water Commission to simulate the ground-water basin to permit an evaluation of the long-term effects of pumping under a variety of basin conditions and water demands (see Appendix 2).

Two alternative projections were modeled: Alternative I, which assumes a nighttime population of 20,500 (and a daytime population of 25,000), and Alternative IV, which assumes an optimistic Fort population of 50,000. The total water demands for the entire study area were used in the model to determine the total impact on the ground-water reservoir. The report by the Arizona Water Commission, however, depicts the situation only within the Fort Huachuca Reservation. The Commission is continuing the study of the water resources of the upper San Pedro valley in connection with its evaluation of the adequacy of water supply for proposed subdivision development (see preceding heading "Economic Development"). Additional data are expected to become available in portions of the study area outside of Fort Huachuca, which will enable the computer model to be further refined. This refinement, which may change some of the details, will not, however, affect the conclusions in the report regarding the adequacy of water at the Fort.

An important aquifer characteristic used in the digital model is the storage coefficient of the ground-water reservoir. There are limited data available to permit an accurate determination of this value. Because of the large impact of the storage coefficient on the drawdown that might be expected from long-term pumping, two sets of storage coefficients were used - one reflecting a very conservative range of values (5 and 10 percent), and the other representing an average value determined for nearby alluvial basins (12 percent), which is considered to be the more reasonable value. Use of the smaller values results in greater drawdown than under the larger value.

The digital model analyses indicate that maximum drawdowns would range from about 50 feet to 80 feet by year 2060 under Alternative I and from about 110 feet to 160 feet by year 2060 under Alternative IV. Inasmuch as the saturated thickness of alluvium in the East Range varies from 650 to 1000 feet, only 10 to 25 percent of the available thickness would have been utilized even under the largest demand. (Plate 4, presenting a cross section of the ground-water basin under the base, depicts the ground-water table under Alternatives I and IV at year 2060, using the conservative storage coefficients, as well as the estimated bottom of the saturated deposits).

The above declines are modest by Arizona standards. However, it is probable that the large withdrawals for Alternative IV (as well as Alternative III), as specified in the model, would dewater portions of the aquifer underlying the present Post well field, as well as portions of the aquifer underlying Sierra Vista, by year 2060. The severity of this impact would depend on the actual thickness of the aquifer in these areas. However, it would be possible in actual operations to moderate this impact

by shifting pumpage to the East Range well field where a greater thickness of saturated alluvium is available. Thus, it can be concluded that the ground water supply is adequate to meet even the largest demand.

The digital model also predicts reductions in the aquifer discharge to the San Pedro and Babocomari Rivers from 20 percent to about 50 percent for the four runs (two sets of alternatives with two sets of storage coefficients). As a result, base flows, as well as the water supply available to vegetative growth along portions of the rivers, possibly would be reduced.

The average maximum declines in ground-water levels predicted by the model would range from 0.6 to 1.8 feet per year. These rates of decline are considerably smaller than the 5-foot average annual rate of decline of ground-water levels in Central Arizona. Records also indicate that total ground-water declines in Central Arizona exceed 300 feet.

Unlike those areas in the United States possessing an adequate surface water supply, the mining of ground water in Arizona is a commonly accepted practice and does not necessarily lead to disaster. Although the annual renewable supply may be small relative to demand, the volumes of water in storage are truly vast and, with proper management and use, can provide a sustained yield for extended periods of time.

CONCEPT DESIGN AND COST ESTIMATES

The Sacramento District retained the services of Blanton and Co., Architects and Engineers, of Tucson, Arizona to develop concept designs and cost estimates for meeting present-day water needs and for expanding the Post's water supply system to meet the needs of populations of 25,000 and 50,000, respectively (daytime figures), at the Post. Detailed information regarding the alternatives considered is given in Appendix 3. All costs presented are capital costs. They do not include costs for engineering and design and for supervision and administration of the construction work. The following material summarizes the conclusions of Blanton and Co.

REQUIREMENTS FOR PRESENT-DAY OPERATION

Under present-day operations (Post population, 12,000), the equipment delivers about 3,090 gallons per minute (gpm). This is not sufficient to deliver the 4.613 million gallons per day (mgd) presently used during the month of May even when pumping is continuous for the entire 24 hours. Changes are recommended in the existing well system and pumping equipment, and pumping and other operating equipment are recommended for Test Well #5, which currently exists only as a drilled, cased, and capped well. A water transmission line would then be constructed to connect Test Well #5 with existing line and electric power would have to be provided. These additions and modifications, which would satisfy the present demand requirements, would cost $810,000 at 1974 prices. The above work would meet the minimum requirements of the Post at this time. If, however, expansion of the Post is contemplated, the proposed water transmission line from Test Well #5 and the electric power line should be sized to meet future requirements. This addition would increase the cost to $920,000 at 1974 prices.

Costs for construction subsequent to 1974 would have to reflect price levels at that time.

The above work and estimates reflect minimum modification to the existing water system for providing a potable water supply for the present Post population. Other additions were suggested by Blanton and Co. for improving the system. Consideration should be given to these suggestions prior to final adoption of a specific program.

REQUIREMENTS FOR A POPULATION OF 25,000

Four wells on the East Range, in addition to Test Well #5, would be placed in service to meet the water requirements for a daytime Post population of 25,000. The cost of adding these four wells with complete pumping equipment and connections to transmission mains and power lines, plus required other modifications in the system to serve the new population, is estimated at $1,410,000 under 1974 prices. This cost assumes that the water transmission line from Test Well #5 and the electric power line were sized for future requirements. The total cost of modifying the existing system to meet present-day requirements and additions and modifications to meet the increased population needs would therefore be $2,330,000 under 1974 prices. Again, costs for construction subsequent to 1974 would have to reflect price levels prevailing at that time.

REQUIREMENTS FOR A POPULATION OF 50,000

Six additional wells on the East Range, in addition to the four East Range wells and Test Well #5 recommended in the preceding paragraph, would have to be placed in service to meet the water requirements for a daytime Post population of 50,000. The cost of adding these six wells with subsidiary equipment plus other required modifications in the system to serve the new population is estimated at $3,850,000 under 1974 prices. The total cost of modifying the existing system to meet present-day requirements and modifications and additions to meet the increased population needs would therefore be $6,180,000 under 1974 prices. Costs for construction subsequent to 1974 would have to reflect price levels prevailing at that time and, in addition, if work were accomplished after 1980, would have to consider replacement of wells and pumping equipment that had served their useful life.

CHARLESTON DAM PROJECT

The Central Arizona Project, authorized for construction by the U. S. Bureau of Reclamation, includes a multiple-purpose reservoir at the Charleston site, which is located just downstream from the old town site of Charleston. The dam proposed for the site would be about 160 feet high and impound a reservoir with a capacity of 238,000 acre-feet, including 116,000 acre-feet for water conservation, 90,000 for flood control, and 32,000 in the inactive pool, including storage for sediment. The reservoir would develop a new supply of 12,000 acre-feet annually. The Arizona Water Commission contemplates that this new water supply could be available for

use in the Fort Huachuca area. Charleston Reservoir, if constructed, could then supply all the projected demands (assuming a Post population of 50,000) in the Fort Huachuca area, including the needs of Sierra Vista and Huachuca City, except for approximately 1,000 acre-feet.

The Bureau of Reclamation has assigned a relatively low priority to the construction of Charleston Dam. Construction of the dam and reservoir is not expected prior to 1985.

DISCUSSION

An appraisal of the ground-water conditions in the upper San Pedro valley, based on data developed by the U. S. Geological Survey, indicates that there is an adequate amount of water in ground-water storage along the upper San Pedro River to meet the forseeable needs of the area. For a nighttime population of 20,500 (and a daytime population of 25,000) at Fort Huachuca, and a study area population of 55,000 in year 2030, assuming no recharge to the ground-water basin, and assuming that producing wells can be located in the area, it would take over 1,200 years to deplete the ground-water basin on the west side. For an assumed Post population of 50,000 and a study area population of 106,500 in year 2030, under the same assumptions as above, it would take about 640 years to deplete the same ground-water area. In addition, about 14,300 acre-feet of water annually, now flowing out of the area or now being consumed by phreatophytes, would either recharge the ground-water basin or could be diverted from the river at such times as ground-water levels were substantially lowered along the river. Such recharge would meet all the demands for a nighttime Post population of 20,500 and study area population of 55,000, (this could extend the life of the ground-water basin indefinitely) and would substantially prolong the life of the ground-water basin under a Post population of 50,000 and study area population of 106,500.

Test well drilling conducted by the Sacramento District concluded that the East Range of Fort Huachuca offers the best potential for the location of new wells and that production wells could be expanded into the East Range as required.

A digital model analysis made by the Arizona Water Commission evaluated the long-term effect of pumping under two alternative projections of population. For a nighttime Post population of 20,500, maximum drawdowns in the area would range from 50 to 80 feet by year 2060; and for a Post population of 50,000, maximum drawdowns would range from 110 to 160 feet by the same year. Such drawdowns are modest by Arizona standards. There is up to 1,000 feet of saturated thickness of alluvium available in the East Range well field. Even with the largest water demands used in the study, the saturated alluvium thickness would have been reduced by only 10 to 25 percent by year 2060.

Concept designs and cost estimates were made by Blanton and Co., an Architect and Engineering firm in Tucson, Arizona, retained by the

Sacramento District. Changes were recommended in the existing water supply system and Test Well #5 was recommended to be brought on line to meet existing deficiencies, at a cost of $810,000 (1974 prices). Such costs would increase to $920,000 (1974 prices) if new lines to be constructed were sized to meet future requirements. Four wells on the East Range, in addition to Test Well #5, would be required to meet the requirements of a daytime Post population of 25,000. The cost of adding these new wells plus required subsidiary equipment and facilities is estimated at $1,410,000 (1974 prices), assuming that the new lines under the deficiency work were sized to meet future requirements. The total cost of the deficiency and expansion program to meet a Post daytime population of 25,000 would amount to $2,330,000 under 1974 prices.

Six additional wells on the East Range, in addition to the four East Range wells and Test Well #5 recommended in the preceding subparagraph, would have to be placed in service to meet the water requirements for a Post population of 50,000. The cost of adding these six wells with subsidiary equipment plus required other modifications in the system to serve the new population is estimated at $3,850,000 under 1974 prices. The total cost of modifying the existing system to meet present-day requirements and modifications and additions to meet the increased population needs of 50,000 would therefore be $6,180,000 under 1974 prices.

All costs presented are capital costs. They do not include costs for engineering and design and for supervision and administration of the construction work. In each case, costs for construction subsequent to 1974 would have to reflect price levels prevailing at that time and, in addition, if work were accomplished after 1980, would have to consider replacement of existing wells and pumping equipment that had served their useful life.

An alternative supply of water would result from construction of Charleston Reservoir, as authorized under the Central Arizona Project. This project would develop a new supply of 12,000 acre-feet annually, which could meet all projected demands for water in the Fort Huachuca area, including the needs of the surrounding communities under a Post population of 50,000, except for approximately 1,000 acre-feet. However, the Bureau of Reclamation has assigned a relatively low priority to construction of Charleston Reservoir and construction of the reservoir is not expected prior to 1985.

The studies presented herein are feasibility scope studies. Upon approval of a desired program, detailed studies will be required before implementation of the upgrading or expansion recommendations.

The proposed expansion programs would involve pumping at greater depths than now being experienced. Recognizing the critical energy shortages and the increased costs of pumping at greater depths, every effort should be made to implement conservation features in future planning. It is noted that the per capita demand on the base is appreciably larger than the use off base.

CONSULTANT'S REPORT

The firm of Harshbarger and Associates, Tucson, Arizona, consultants in hydrogeology, was hired as a consultant in the study effort. Their report is included as Appendix 1. The conclusions reached by the consultant firm are as follows:

1. Adequate volumes of recoverable ground water are present in the regional aquifer to satisfy the maximum projected water demand. It is conservatively estimated that the volume of recoverable ground water in storage in the regional aquifer is 8 to 15 times greater than the total projected water demand.

2. Projected water requirements for a military population of 50,000 could be satisfied by construction of the proposed well field on the East Range. Drawdown in the proposed well field after 80 years of pumping would be on the order of 60 to 110 feet.

3. Future interference effects with civilian ground-water users in the area are of acceptable magnitude, with a proper management plan. The depression cone developed by the proposed East Range well field would not cause significant infiltration of water in the channel of the San Pedro River.

4. Future refinement of the digital model will improve the agreement between simulated and measured water levels in some areas. The magnitude of predicted drawdown in the regional aquifer will not be significantly affected by these future model refinements.

CONCLUSIONS

The District Engineer concludes that:

1. Adequate ground water is available in the upper San Pedro River basin to support future growth in Fort Huachuca and surrounding areas.

2. Production wells can be located in the East Range of Fort Huachuca.

3. The capital costs of modifying the existing water supply system to meet present deficiencies, plus inclusion of provisions for future expansion, are estimated at $920,000 (1974 prices).

4. The total capital cost of modifying the existing water supply system to meet present deficiencies and of expanding the Post's water supply system to meet an assumed daytime Post population of 25,000 is estimated at $2,330,000 (1974 prices).

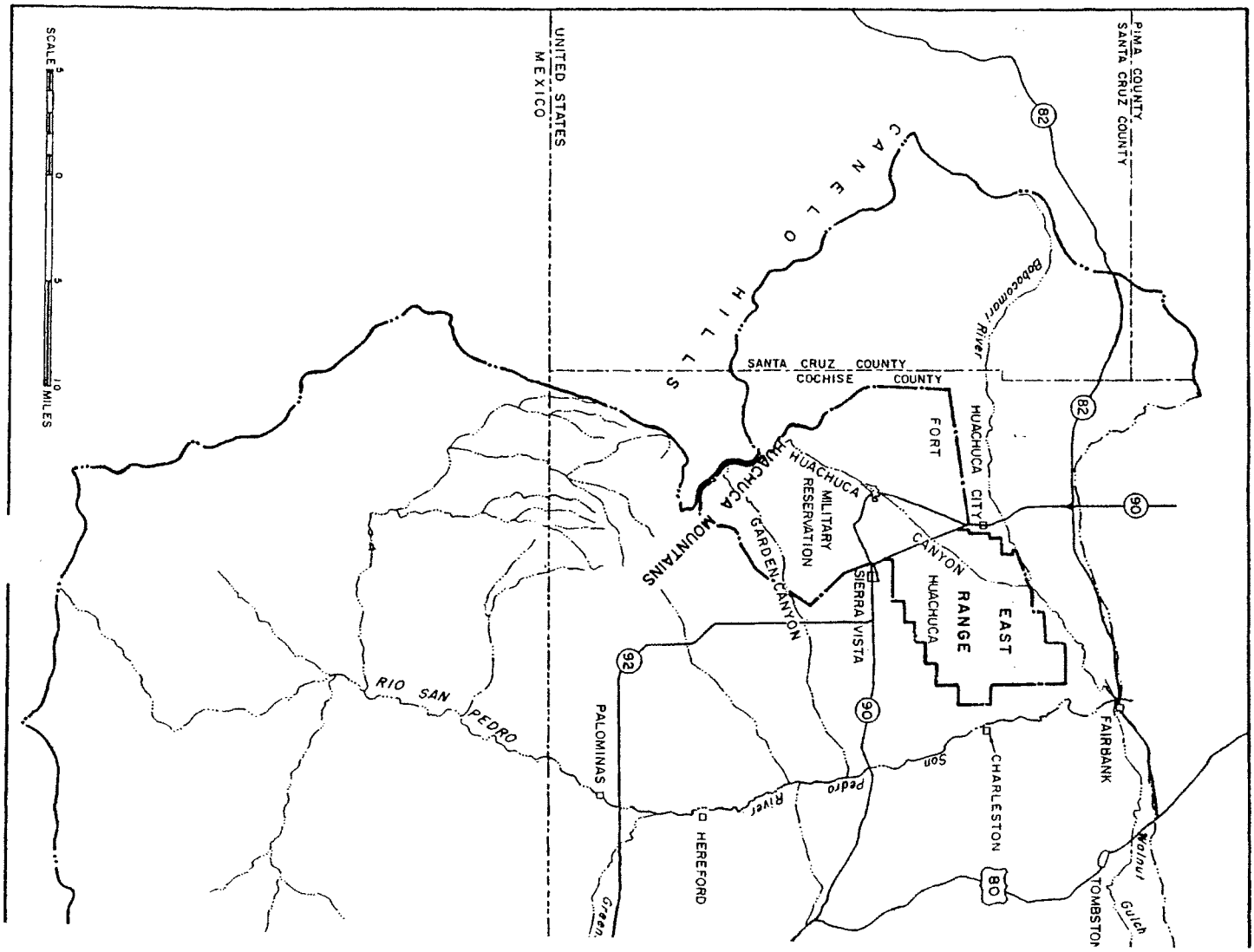
5. The total capital cost of modifying the existing water supply system to meet present deficiencies and of expanding the Post's water supply system to meet an assumed daytime Post population of 50,000 is estimated at $6,180,000 (1974 prices).

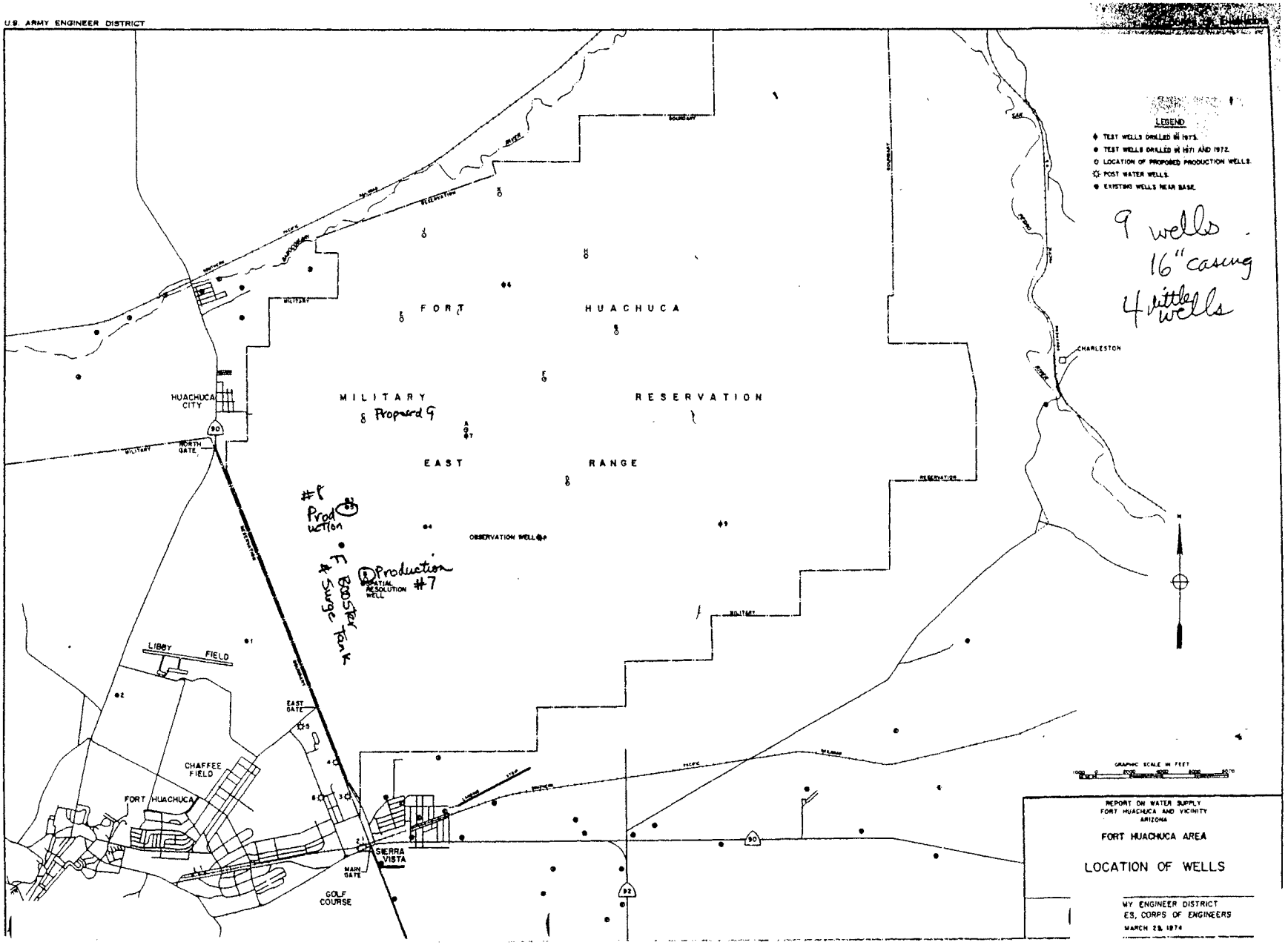
6. All costs presented are capital costs. They do not include costs for engineering and design and for supervision and administration of the construction work. In each case, costs for construction subsequent to 1974 would have to reflect price levels prevailing at that time and, in addition, if work were accomplished after 1980, would have to consider replacement of existing wells and pumping equipment that had served their useful life.

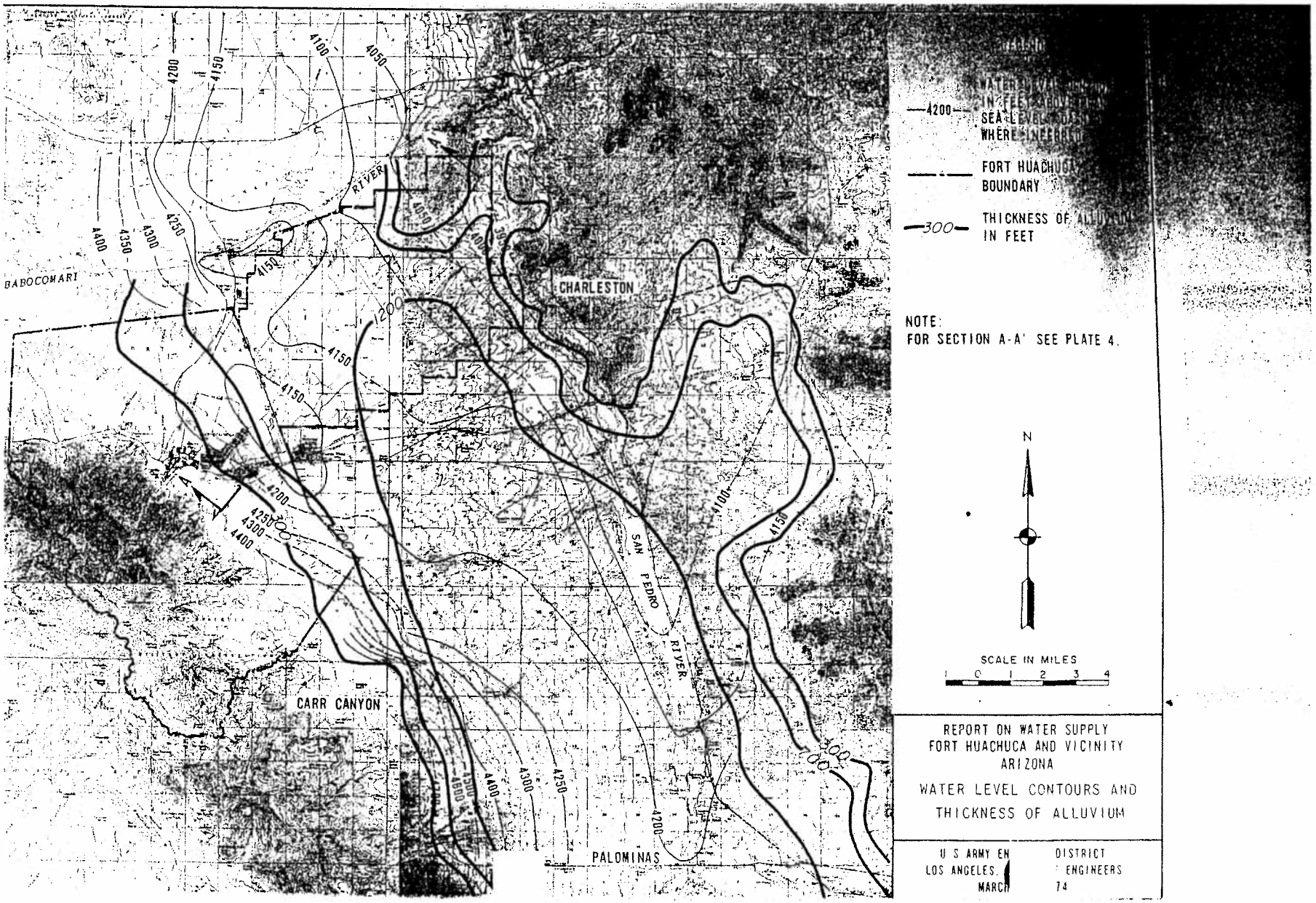
7. An alternative supply of water would result from construction of Charleston Reservoir, as authorized under the Central Arizona Project. This project would meet all projected demands in the Fort Huachuca area under a Post population of 50,000, except for approximately 1,000 acre-feet. However, the Bureau of Reclamation has assigned a relatively low priority to construction of Charleston Reservoir and construction of the reservoir is not expected prior to 1985.

RECOMMENDATIONS

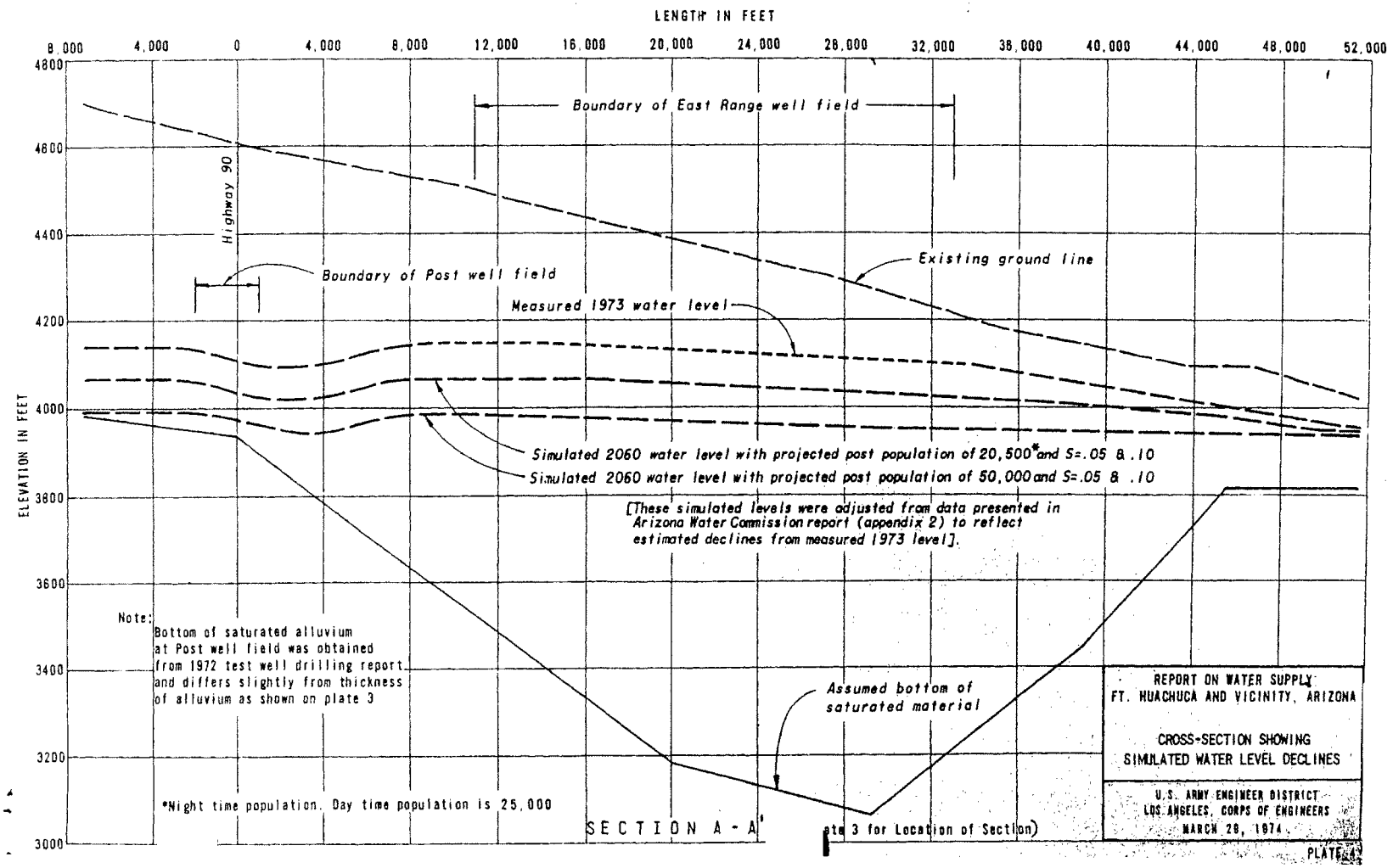
The District Engineer recommends that this report be used as a basis for future planning for Fort Huachuca. The District Engineer further recommends that detailed studies be made to implement any Post expansion program and that such studies should be made in cooperation with the Arizona Water Commission, the U. S. Geological Survey, and other interested agencies.


SCALE
5
0
5
10 MILES
UNITED STATES
MEXICO
PIMA COUNTY
SANTA CRUZ COUNTY
SANTA CRUZ COUNTY
COCHISE COUNTY
CANELO HILLS
Babocomari River
HUACHUCA MOUNTAINS
HUACHUCA
MILITARY
RESERVATION
FORT
HUACHUCA
CITY
GARDEN CANYON
CANYON
HUACHUCA
EAST
RANGE
SIERRA VISTA
RIO SAN PEDRO
PALOMINAS
HEREFORD
San Pedro River
Green
CHARLESTON
FAIRBANK
TOMBSTONE
Walnut Gulch
82
90
92
80


U.S. ARMY ENGINEER DISTRICT
LEGEND
TEST WELLS DRILLED IN 1971.
TEST WELLS DRILLED IN 1971 AND 1972.
LOCATION OF PROPOSED PRODUCTION WELLS.
POST WATER WELLS.
EXISTING WELLS NEAR BASE.
9 wells
16" casing
4 little wells
FORT HUACHUCA
MILITARY RESERVATION
EAST RANGE
Proposed 9
#8 Production
#7 Production
Booster & Surge Tank
OBSERVATION WELL
HUACHUCA CITY
NORTH GATE
EAST GATE
MAIN GATE
LIBBY FIELD
CHAFFEE FIELD
FORT HUACHUCA
SIERRA VISTA
GOLF COURSE
CHARLESTON
GRAPHIC SCALE IN FEET
REPORT ON WATER SUPPLY
FORT HUACHUCA AND VICINITY
ARIZONA
FORT HUACHUCA AREA
LOCATION OF WELLS
ENGINEER DISTRICT
CORPS OF ENGINEERS
MARCH 1974


4200
WATER LEVEL IN FEET ABOVE SEA LEVEL (USGS) WHERE INFERRED
FORT HUACHUCA BOUNDARY
300
THICKNESS OF ALLUVIUM IN FEET
NOTE:
FOR SECTION A-A' SEE PLATE 4.
N
SCALE IN MILES
1 0 1 2 3 4
REPORT ON WATER SUPPLY
FORT HUACHUCA AND VICINITY
ARIZONA
WATER LEVEL CONTOURS AND
THICKNESS OF ALLUVIUM
U S ARMY EN
LOS ANGELES,
MARCH
DISTRICT
ENGINEERS
74
BABOCOMARI
CHARLESTON
CARR CANYON
PALOMINAS
SAN PEDRO RIVER
RIVER
4100
4050
4150
4200
4250
4300
4350
4400
1200
300

USFH283


LENGTH IN FEET
8,000
4,000
0
4,000
8,000
12,000
16,000
20,000
24,000
28,000
32,000
36,000
40,000
44,000
48,000
52,000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
ELEVATION IN FEET
Boundary of East Range well field
Highway 90
Boundary of Post well field
Existing ground line
Measured 1973 water level
Simulated 2060 water level with projected post population of 20,500* and S=.05 & .10
Simulated 2060 water level with projected post population of 50,000 and S=.05 & .10
[These simulated levels were adjusted from data presented in Arizona Water Commission report (appendix 2) to reflect estimated declines from measured 1973 level].
Note: Bottom of saturated alluvium at Post well field was obtained from 1972 test well drilling report and differs slightly from thickness of alluvium as shown on plate 3
Assumed bottom of saturated material
*Night time population. Day time population is 25,000
SECTION A - A'
te 3 for Location of Section)
REPORT ON WATER SUPPLY
FT. HUACHUCA AND VICINITY, ARIZONA
CROSS-SECTION SHOWING
SIMULATED WATER LEVEL DECLINES
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
MARCH 28, 1974
PLATE 4